The investigation of ear asymmetry by simple and disjunctive reaction-time tasks[1]

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In a disjunctive reaction-time task in which Ss responded to clicks presented to one ear while white noise was presented to the other, RT was significantly faster to stimuli presented to the left ear than to the right ear. In a simple reaction-time task, using the same stimuli, there was no difference in RT to stimuli presented to right or left ear. The results were discussed in relation to functional asymmetry of the cerebral hemispheres, and were taken to support a perceptual interpretation of the ear asymmetry effect.

Experiments demonstrating ear asymmetry in the recognition and recall of dichotically-presented stimulus material have been related to functional asymmetry of the two hemispheres in man. The left hemisphere is dominant for speech in most right-handed Ss, and right ear performance is superior to left ear performance in recall of pairs of digits presented dichotically (Bryden, 1963). When the task is nonverbal, left ear performance is superior (Kimura, 1964) suggesting a predominant role of the right hemisphere in the analysis of nonverbal stimuli. Studies of patients who have undergone unilateral temporal lobectomy support this interpretation (Milner, 1962; Shankweiler, 1966). Right temporal lobectomy results in a greater decrement in performance on nonverbal auditory tasks, left temporal lobectomy in a greater decrement on verbal auditory tasks.

The ear asymmetry effect is generally observed only under conditions of dichotic stimulation (Dirks, 1964), and this finding has been related to physiological evidence of greater amplitude of evoked response to contralateral than to ipsilateral auditory stimulation and to evidence that under conditions of binaural stimulation, ipsilateral connections are partially occluded by contralateral ones, thus accentuating the crossed pathways (Rosenzweig, 1951).

Some controversy exists concerning the role of perceptual, memory, and attentional processes in the ear asymmetry effect (Inglis, 1965; Oxbury, Oxbury, & Gardiner, 1967; Satz, 1968; Treisman & Geffen, 1968). Most of the experiments in this area have involved the presentation of stimuli of a duration that necessarily entails some memory load; performance has been measured by recognition and recall methods; and dichotic stimulus presentation has necessitated division of attention. This makes it difficult to establish whether the resulting stimulus "trace" is less adequately established in the nondominant hemisphere because of unequal attention distribution or unequal discriminative capacity, or if both hemispheres are equal in the perception of the stimulus, but differ in storage or retrieval mechanisms.

In a preliminary study, a nonverbal task that involved neither memory load nor division of attention was used, and gave evidence of superior left ear performance. In this task, pairs of clicks were presented to the S and his performance in detecting two clicks at small interclick intervals measured. It was found that pairs of clicks presented to the left ear were better resolved than pairs of clicks presented to the right ear and that this difference between ears was accentuated when a burst of white noise was presented to the ear contralateral to that receiving the clicks, in accordance with Rosenzweig's (1951) model.

These results suggested that the ear asymmetry effect might be primarily a perceptual one, the right hemisphere playing a predominant role in the perception of nonverbal stimuli. The experiments described below were designed to investigate further the role of perceptual processes in ear asymmetry with nonverbal stimuli. If information reaches the right hemisphere more quickly or with greater perceived intensity, the ear asymmetry effect should be demonstrated in both simple and disjunctive RT. If the left hemisphere receives less information, or codes information received less efficiently, or transfers it to the dominant hemisphere for analysis, an ear asymmetry effect would be predicted for disjunctive RT but not for simple RT. Since the experimental task does not involve memory load or division of attention, no ear asymmetry would be predicted for disjunctive or simple RT if memory or attention factors are predominant in the ear asymmetry effect.

EXPERIMENT 1

Method

Twenty unversity students were used as Ss; 14 were male and six female. All Ss were right handed and their age range was 18 to 28 years. Clicks were delivered monaurally through Brown Type K earphones, energized by square pulses delivered from stimulators triggered by a sequence timer that controlled the interval between the pulses. The intensity of the clicks was approximately 85 dB above threshold. In order to bring about the partial occlusion of ipsilateral pathways, white noise, approximately 60 dB above threshold was delivered to the ear contralateral to that receiving the click stimuli. It commenced 100 msec before the first click and was of 200-msec duration. A millisecond timer with an "in-line" display was triggered simultaneously with the first click, and was stopped by release of one of the microswitches on a response panel. Both stimuli consisted of two clicks, 0.1 msec in duration. For Stimulus 1, the two clicks were delivered simultaneously from the two stimulators. Stimulus 2 was two clicks separated by 10 msec. Reference to the characteristics of the earphones suggested that the energy content of the single and double click stimuli was approximately equalized, and Ss should not be able to discriminate the stimuli by intensity differences. Since the average threshold of fusion for two clicks in normal Ss is approximately 2.5 msec this was a relatively easy discrimination task.

Ss were seated in a lighted, sound-attentuating cubicle, with the index fingers of the right and left hand on two microswitches on a response panel. For half the Ss, response to Stimulus 1 was made by releasing one microswitch with the index finger of the right hand and the response to Stimulus 2 by releasing the other microswitch with the index finger of the left hand. For the remaining Ss, this stimulus/response relationship was reversed.

Ss were given samples of the two stimuli and instructed to release the appropriate microswitch as quickly as possible. They were given an initial training period of 20 trials. Incorrect responses were rare (no S made more than two), and when these occurred, the trial was repeated.

Two blocks of trials were presented to each ear in order RLLR or LRRL to alternate Ss. In each block of 50 trials, 25 of them stimuli were presented. Order of stimulus was random with the restriction that no sequence of more than four of the same stimuli was given. Before each block, Ss were told to which ear stimuli would be presented in the following block. Ten practice trials were given at the beginning of each block. The intertrial interval was approximately 5 msec.

Results

Median RT's for each condition were calculated for each S, and mean values of these scores are shown in Table 1. the mean median RT to the right ear was 510 msec and to the left ear stimuli was 492 msec.

An overall analysis of variance was carried out on these data. The difference between ears was significant ($F = 10.22$, $df = 1,19$, $p < 0.01$). Inspection of Table 1 shows that a larger practice effect is shown with Stimulus 1 than Stimulus 2 and that this is shown most markedly on the right ear (Ears by Stimuli by Blocks: $F = 14.48$, $df = 1,19$, $p < 0.01$). Stimulus 1 appears to have been the more difficult stimulus to discriminate although the difference in RT with the two forms of stimuli was not significant ($F = 3.87$, $df = 1,19$, N.S.). Several Ss reported that they coded the stimuli as "2" or "not 2." The negative concept of Stimulus 1 appears to have been the more difficult. Alternatively, Ss may have waited longer for a second click to be presented before responding to Stimulus 1. No other main effects or interactions were significant.

Because of the significant Ears by Blocks by Stimuli interaction, further analyses were preformed only on Block 2 data, the data of Block 1 being considered as practice trials, since Block 2 data more nearly represent steady-state performance. An analysis of variance on Block 2 showed a significant difference in RT between ears ($F = 11.58$, $df = 1,19$, $p < .0.01$). Variance ratios due to stimuli, response hand, and interactions were not significant.

Thus, the experiment shows that in a task with dichotic stimulation and requiring stimulus discrimination, RT to a nonverbal stimulus presented to the left ear is faster than RT to a stimulus presented to the right ear.

Table 1
Mean Disjunctive RT

	Left Ear		Right Ear	
Block	1	2	1	2
Stimulus 1	506	491	532	514
Stimulus 2	491	481	500	497

EXPERIMENT 2

Method

Twenty university students were used as Ss; 13 were male, seven female. All Ss were right handed and their age range was 18 to 28 years. Apparatus and method were exactly as described for Experiment 1 with the following modifications: (1) No discrimination between the two stimuli was required of the Ss, and responses were made with the index finger of the same hand to both stimuli. The response hand was changed at the end of each block, and order of right and left hands was counterbalanced; (2) in order to avoid response anticipation, in the form of response to noise onset rather than click, the onset of noise was varied randomly between 80 and 120 msec before the first click.

Results

Median RT's for each condition were calculated. Since the task was simple RT, and since there was clearly no difference between RT's to the stimuli (mean RT to Stimulus 1 and Stimulus 2 = 216 msec), scores for both stimuli were combined in the analysis. Mean scores are shown in Table 2. An analysis of variance showed no significant effects of ears, response hand, blocks, or any interaction. All F rations were less than 1.0 except for the Ears x Blocks interaction ($F = 2.15$, $df = 1,19$, N.S.).

Table 2
Mean Simple RT

Ear	Left	Right
Block 1	216	221
Block 2	216	211

DISCUSSION

The results of these two experiment show that there is no difference between ears in a simple RT task but that in a disjunctive RT task involving discrimination of nonverbal stimuli, RT is faster to stimuli presented to the left ear.

In the disjunctive RT task, Stimulus 1 proved the more difficult stimulus to discriminate, and the right ear showed a greater practice in discrimination of this stimulus than did the left ear. However, the difference between ears was still significant when the effects of practice had been minimized when Block 2 data were analyzed separately. The difference between stimuli was not clearly one of intensity since there was no difference between stimuli in the simple RT task. The differential difficulty in coding of the two stimuli was unexpected. Nevertheless, although it adds complications to the interpretation of the results obtained, the experiments provide support for the preliminary findings that the detection of two clicks is performed more accurately when clicks are presented to the left ear, and that the ear asymmetry effect appears to be a perceptual one and reflects differences in function of the right and left cerebral hemispheres.

The results of the simple RT task confirm Simon's (1967) finding that there was no difference in simple RT to a nonverbal stimulus presented to the right or left ear when the Ss knew which ear was to be stimulated. However, Simon also reported that when stimuli were presented randomly to the right or left ear, RT was faster to stimuli presented to the right ear. This suggests that a right ear attention bias may play a part in the ear asymmetry effect, but that when its role is minimized a perceptual asymmetry may be revealed.

With reference to the various postulated causes of the ear asymmetry effect discussed in the introduction, the results suggest that the effect is a function of perceptual and coding processes, and that speed of coding may be an important element. The experiments reported here do not permit any selection between the possibilities that the effect is due to differences in the amount of information received, in the efficiency of analysis of information, or in interhemispheric transfer of information for analysis. Simon and Rudell (1967) found that disjunctive RT of the right and left hand to the verbal stimuli "right" and "left" were fastest when the content of the command corresponded with the ear stimulated, i.e., right ear/right hand and left ear/left hand RT's were fastest. Although it is possible that stimulus/response compatibility factors of this nature were also involved in Experiment 1, their effect was clearly not great since right ear/right hand RTs were slowest and variance ratios due to response hand were not significant.

The results suggest that functional differences of the right and left hemispheres can be investigated by RT tasks. Experiment 1 reveals a left ear superiority in RT to a nonverbal stimulus.

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NOTES

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